LIFE HISTORY OF THE WESTERN WATER PENNY BEETLE, *PSEPHENUS FALLI* (COLEOPTERA: PSEPHENIDAE)

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ABSTRACT

Psephenus falli, the western water penny beetle, living in the Pacific coast states and Idaho, probably requires 15-18 months to complete its life cycle. Much growth variation exists even among those developing from the same egg mass. Life history is shorter than that postulated for the eastern species, *P. herricki*, but the microdistribution, habitat distribution, and behavior of all life stages seem identical to that species.

INTRODUCTION

Several authors (Matheson 1914, West 1929, Schafer 1950) have produced life history studies of *Psephenus herricki* (DeKay), the water penny beetle living in eastern United States and Canada. Murvosh (1971) incorporated life history data into an autecological study attempting to explain and understand the habitat and geographical distribution. Two new species have been described recently (Brown 1970; Brown and Arrington, 1967), but little biological information has appeared except studies on parasitism (Burks 1968; Brown 1968). Murvosh, Spangler, and Brown (unpublished data) worked out the Nearctic distribution, and Brown and Murvosh (in manuscript) revised the genus and described some new species from Arizona.

Life history information on the western members of this genus is lacking. Ecological studies over the past 8 years have yielded a certain amount of life history data, and the purpose of this paper is to assemble what is known about the far western species, *P. falli* Casey. The study was designed to give a general overview of life history, and no attempt was made to work out certain details such as the exact number and description of instars. Certain areas will be pointed out that require additional study and comparisons made with the eastern species.

Casey described *P. falli* from a unique male from southern California apparently without examining specimens of the previously described *P. haldemani* Horn from Baja California. Two more species, *P. veluticollis* and *P. calaveras*, were described from California and *P. lanei* from Idaho, but these are all the same as *P. falli* (Brown and Murvosh, in manuscript). A potentially unsolvable problem exists in trying to determine if *P. haldemani* and *P. falli* are the same. The description of *P. haldemani* was based on 2 females taken from an unknown type locality in Baja. This locality will probably never be determined and species determinations are made on male specimens. Brown

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and Murvosh (in manuscript) reviewed this problem and based on color difference, size, and some disjunction, think it best to tentatively consider the Baja population separate from that occurring in the U. S. Considering this, the genus distribution map published by Murvosh (1971) is slightly in error. The problem seems solvable only if one species of *Psephenus* occurs in Baja.

Common names for species have not yet been proposed for this group, but some consideration should be given to this since several species are now known and biological data is accumulating. We are using western water penny beetle as a tentative common name for this species.

Acknowledgments

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Methods

Life history data was collected in both the field and laboratory. Collections and observations were made throughout the entire range of the species, but most of the work concentrated in 2 streams in southern California. Deep Creek drains part of the San Bernardino Mountains near Lake Arrowhead and flows north to join the Mojave River 15 miles south of Victorville. Big Rock Creek flows north out of the San Gabriel Mountains, enters and crosses the San Andreas Fault at Valyermo and disappears into an alluvial fan about 15 miles southeast of Palmdale. Drainage in both streams is interior.

The different life stages of this insect were field collected and taken to the laboratory for rearing. Newly laid eggs are easily determined if the ovipositing female is present. Rocks with such eggs were brought to the laboratory to determine hatching time. The growth rate of immatures under laboratory conditions was estimated by sorting field samples of larvae into different (2, 3, 4, 5, 6, 7 mm) size classes. Each size class was put into separate rearing containers and monthly measurements made to calculate the average time required for each group to grow to the next size class.

Water pennies can be maintained in the laboratory in containers as simple as plastic bowls and aquaria, if sufficient light and algae coated rocks are present. Aeration of the water is very desirable but seems unnecessary on a continuous basis. The containers required frequent cleaning of scum and debris and the water exchanged to inhibit a slimy bacterial growth which formed on some rocks. Chlorinated tap water does not appear harmful, but we routinely aerated this water for 30 minutes or allowed it to stand for 24 hours before use.

Stock populations of water pennies were kept in rectangular (30 × 25 × 15cm) plastic wash tubs. Larvae, sorted to various size classes, were put in round (15 × 15cm) plastic half gallon ice cream containers. Two holes, each 5cm square, were cut out of the containers, 2cm above the bottom and nylon screening was glued on. The half gallon rearing containers were put into a 120cm circular plastic swimming pool 20cm deep. The water in the pool was maintained at a level 5cm from the top and oxygenated continuously. The containers were exposed to sunlight (200-1600 foot candles) through a large laboratory window. The tops of the containers were uncovered as there was no evidence of larvae migrating from one container to another.

Field growth rates were estimated by periodically collecting samples of larvae and constructing frequency distributions of size classes plotted against number. This gives an idea of the temporal distribution of the various size classes. Measurements were made in the field with dial calipers and larvae returned to the stream. Other field observations of a less quantitative nature yielded similar data.

It is almost impossible to determine in the field the time required for pupation. Data was obtained by holding mature larvae and prepupae in moist glass vials in the laboratory. Adult life span cannot be properly studied in the field either. Field collected adults and those emerging from pupae were kept in containers with moist rocks and cotton to study longevity.

Life History

The Adult Beetle

Adults are typically found on the lee and sides of wave-splashed rocks in stream riffles. They are very difficult to see when standing motionless at the rock water interface, but they periodically run back and forth along the wet surface and are more easily seen. The habitat, microdistribution, and behavior seem identical to those of *P. herricki* (Murvosh 1971).

Males (3.3-4.3mm) are somewhat smaller than females (3.8-5.1mm); apparently true for all species studied in this genus. Adults are generally present from early May to about the middle of August (Table 1) but not necessarily in all localities. In southern California, for example, they were collected in early May in Big Rock Creek but not seen until June in Deep Creek. An area should be sampled at least 2 years before any conclusions are drawn regarding temporal distribution. Sampling in Big Rock Creek in 1970 suggested that adults emerged in late May and early June and vanished by July. Studies the following year showed that they were present in this stream from early May to mid-August. Populations in Big Rock Creek are not as large as those in Deep Creek and there may not be a continuous adult emergence such as probably occurs all summer in Deep Creek. Gaps in emergences plus low population densities could lead to unwarranted generalizations.

There is not enough data to give a complete picture of adult temporal distribution in Idaho and Oregon. The May to August time distribution occurs in a great enough variety of streams and geographic locations that genetic factors probably exert more control over emergence than extrinsic factors. In most locations, July seems to be the best time to collect adults.

An individual beetle is probably not around very long. Laboratory data suggest that both males and females can live about a week. A new tagging method will give better information in the future as to what actually happens in the field. Females enter the water immediately to lay eggs in the substrate and then die. These females have a characteristic "dirty" appearance and have never been known to leave the stream bed. They probably have a field life span of 1 to 3 days.

Eggs

The lemon yellow eggs of this species are deposited close together in single layers forming a mass of about 500. Several females often oviposit together forming a large mass sometimes containing 2,000 eggs. Eggs are deposited on the undersurfaces of rocks in riffles but particularly those areas of a riffle where wave-splashed rocks project above the water line. One exception to this was seen on the Clearwater River in Idaho where females were ovipositing near the shore in water void of any turbulence.

Eggs of this species have yet to be examined microscopically for differences from *P. herricki*. Superficially at least, all water penny beetle eggs look very much alike and occur in masses about the same size.

They have been found in Big Rock Creek from the first week of May to the second week in August. In Deep Creek, they have been seen from mid-June to mid-August. In northern California in the Trinity River drainage, eggs also have been collected as late as August 14. Egg hatch took 16-17 days in the laboratory in water at 23°C, but this should be studied again since we experienced difficulty getting some eggs to hatch and could not determine the cause. This hatching time is comparable to, but slightly longer than, the 12-15 days reported for *P. herricki* (Schafer 1950; Davis 1965). The newly hatched larva, about 0.75mm long, is whitish or colorless and can't be seen with the naked eye when on a naturally-occurring substrate. Egg hatch seems high (75-90%), but survivorship data beyond this is unknown for any species in this genus. Two unmated, laboratory reared females laid eggs, but these did not hatch, casting doubt that parthenogenesis occurs.

Pupae

The macro- and microdistribution of prepupae (mature larvae) and pupae under rocks along the shorelines of riffles seem identical to that of *P. herricki*. They are often distributed in such a highly contagious manner that they are difficult to sample accurately. We spent little time studying this stage and did not attempt to describe the pupa or the exact time period required for pupation. Physical descriptions of this whole process are needed. Limited data suggest that 2 weeks are required, but our rearing conditions were far from normal. If the pupation process takes about 2 weeks, then pupae should occur in the field from late April to early August. One pupa was found in Deep Creek as late as 12 August. Pupation takes 10-12 days in *P. herricki*, and the temporal distribution is from late May to early September.

The Larva

Some idea of the temporal distribution of larvae is indicated by graphs in Fig. 2. These data, plus others collected in the field, show that several sizes (but not necessarily all) of larvae are present the entire year. Although we did not directly attempt to find the exact number of instars, laboratory data suggest a minimum of 4, and we speculate somewhat in suggesting 6. A comparison of these data with those collected for *P. herricki* indicates a difference in life history to some extent. All sizes of *P. herricki* larvae can be found throughout the year (Murvosh 1971), suggestive of the 2 year life history postulated by West (1929) and Schafer (1950).

Small larvae could not be found in a winter collection at Big Rock Creek suggesting that the last eggs of the previous season had developed to 4-5mm larvae. The size classes present in Deep Creek by mid-August show that most larvae are in the 2-3mm stage. A similar distribution, not shown here, was found the same time the following year. If these represent the last laid eggs, then larvae may grow to this size in about a month or so. The collection from the Trinity River area was biased somewhat toward the larger sizes and does not accurately represent the relative numbers of small larvae. Considering this bias, a minimal growth rate for the entire summer would be 3-4mm. In general, the field data are suggestive of a minimal summer's growth from egg to 3 or 4mm, with the possibility that the fastest growing larvae may do this in much less time.

Laboratory rearing demonstrated that a tremendous amount of variability exists in growth patterns, even among individuals hatching from the same egg mass. The average growth rate for laboratory reared larvae was about 1mm per month. Larvae from a Big Rock Creek egg mass developed to 2.5 and 3.5mm in 3 months, but this was on rocks where the nutrient supply was possibly inadequate.

It seems reasonable, in view of both laboratory and field data, to postulate an egg to egg life history development time of 15 months based on an average field growth rate of 1mm per summer month. A 1mm first instar in May could overwinter as a 5mm larva, if it grows during September, and reach the last instar the following May or June. Pupation, emergence, and oviposition during June and/or July would give a 14-15 month life cycle. The fastest growing larva, after hatching in early June, might overwinter as a 5 or 6mm larva, completing development the following spring with a 1 year life history. Some laboratory larvae grew little more than 0.5mm per month. If this represents genetic growth and not poor nutrition, then some individuals would need 2 full years to complete the life cycle. Pupation occurs under the covering of the exoskeleton of the last instar, and measurements of these skins show the last instar ranges from 6 to 8.5mm. Females are generally larger, although a 4.3mm female emerged from a 6.3mm last instar. Field and laboratory data suggest that larvae reaching maturity in late summer (August) do not complete development, but they overwinter and emerge the following year. Some larvae probably overwinter twice. Eggs laid in August could produce a 2mm overwintering larva which could develop to maturity the following summer and overwinter again. In such cases, a complete life cycle would take 20 months or more.

We feel that a life history of either 1 or 2 years is probably unusual and suggest that 15-18 months is more realistic for California beetles. More data is needed to generalize about Idaho and Oregon beetles. Tremendous growth variability exists in this species and a great deal of variation is to be expected in life history. This makes it impractical to propose a specific narrow time range. There is also a certain amount of opportunism involved. Individuals from eggs laid at the "wrong time" may have to spend 2 winters in the water resulting in a longer development time. More information is needed about 2 specific time periods: how much growth and development actually occur in September and October and the spring months? If the growth rate is faster than we suspect at these times, then the life history is shorter than postulated. We have seen some distributions that are puzzling. We could find no larvae other than matures near pupation sites in early May in Big Rock Creek. This

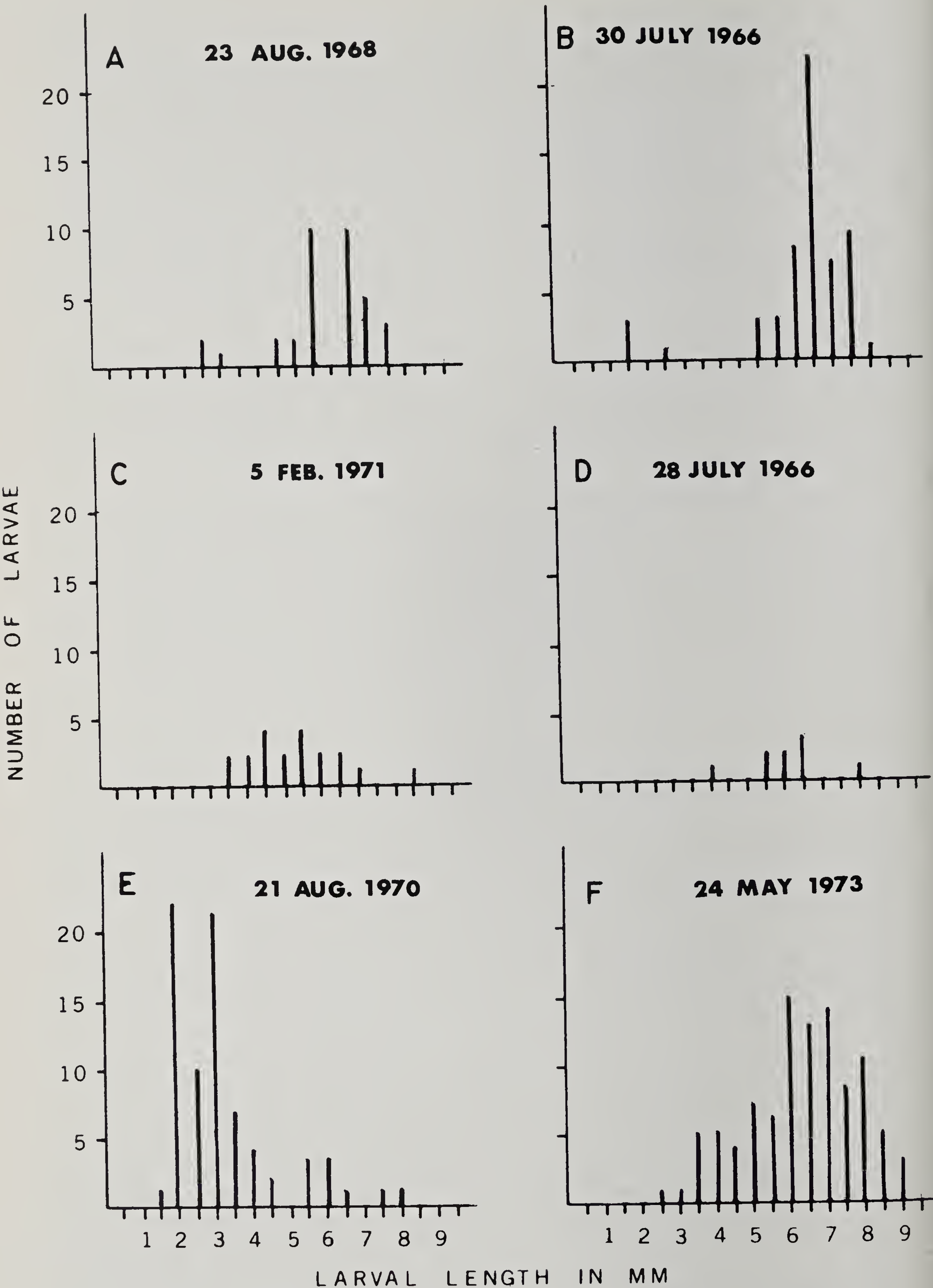

Fig. 1. Temporal distribution of various size classes of *P. falli* larvae. A. Salt Creek, Peanut, California. B. Julietta, Idaho. C. Big Rock Creek, Valyermo, California. D. Clearwater River, Kamiah, Idaho. E. Deep Creek, San Bernardino Mountains, California. F. Deep Creek.

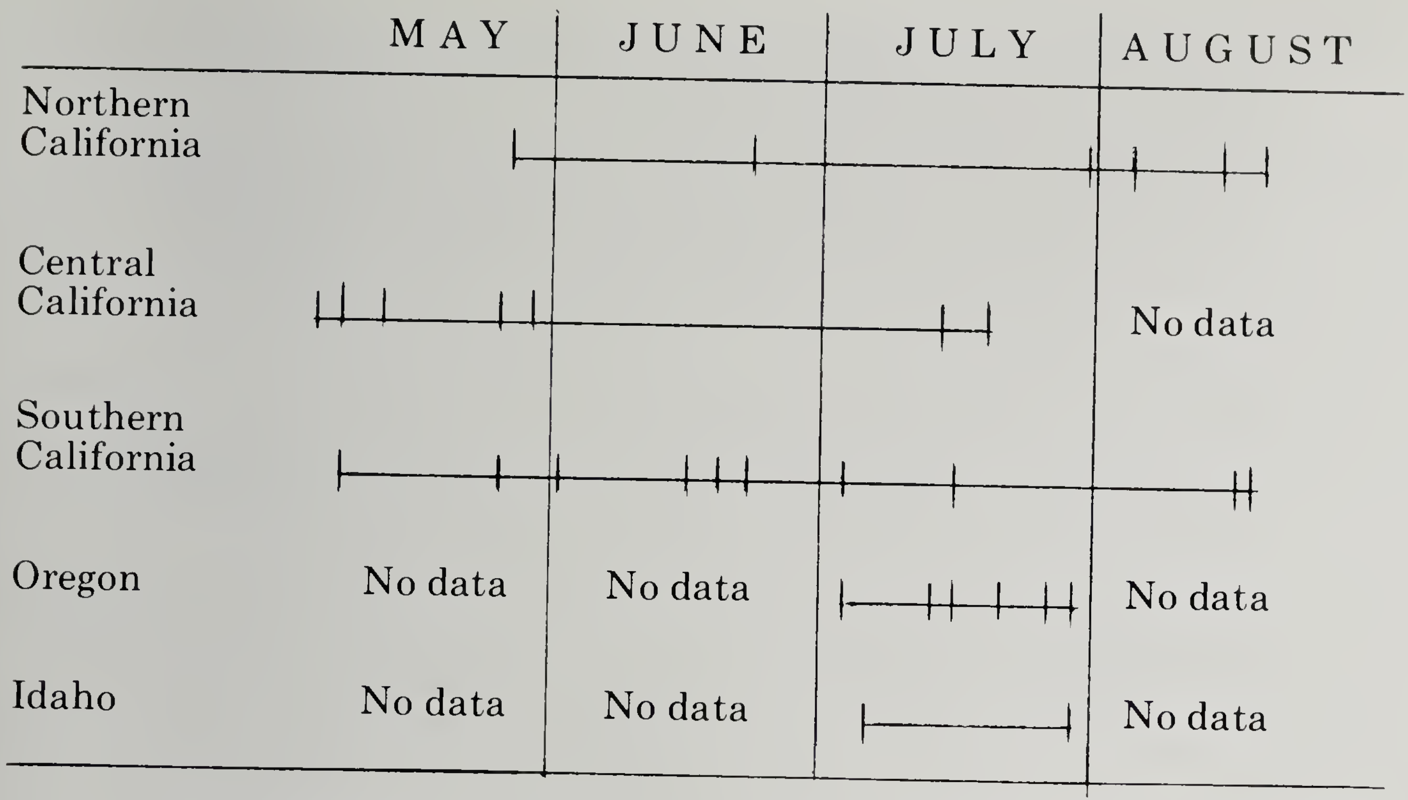

TABLE 1. The temporal distribution of adult *Psephenus falli* in western United States.

is suggestive of a 1 year life span if the sampling error was small. In May, in Deep Creek, a similar distribution was seen except that some 2-3mm larvae were present. A Deep Creek riffle, 300m above this, was full of mature larvae in August. No 1 or 2mm individuals could be found, and those under 5mm were rare, suggesting a very rapid summer growth. The riffle 300m below on this same date was full of small (2-3mm) individuals, and mature larvae were difficult to find. This seems to suggest 2 populations, relatively isolated in the same stream, developing separately. Another unusual temporal distribution was seen in Idaho during July 1966. Adults were common and larvae uncommon along the Clearwater River, but the reverse situation was true 2 days later on the Potlatch River about 80 miles away.

Psephenus falli and *P. herricki* are very much alike except that they occur in 2 different geographic locations. Morphologically they look very much alike except that *P. falli* is smaller. The behavior, habitat distribution, and life history are similar. The major difference is that *P. herricki* seems to require a longer time to complete the life cycle.

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BOOK REVIEWS

The following 2 recent books have been published by W. Junk, Publishers, 13 van Stolkweg, The Hague, Netherlands. Both are monumental treatises on families of beetles, for which the publisher should be commended for producing. Even with the great dedication of the authors in conducting the research, it is often difficult to obtain commitments for printing such specialized books.

Monographie der Familie Platypodidae (Coleoptera) by Karl E. Schedl. 1972. v + 322 p.; 73 fig. 70 Dutch Guilders

Dr. Schedl has devoted over 50 years to the study of this economically important family and owns the World's largest collection of them. This, his greatest contribution, contains everything " . . . which is necessary for an understanding of the complex biological aspects together with a systematic section including determination keys for the sub-families and genera." The text is in German.

Biology of Coccinellidae by Ivo Hodek. 1973. 260 p.; 58 photos; 34 plates. 100 Dutch Guilders.

Three chapters are separately authored: 1) Taxonomy and morphology of adults, by I. Kovar; 2) Morphology and taxonomy of the larvae with keys for their identification, by G. I. Savoiskaya and B. Klausnitzer; 3) Variability and genetic studies, by A. Honek. A pictorial color key to 4th instar larvae and a simple field key (by Klausnitzer and Kovar) is attached in an envelope so that it can be removed for field use. The text is in English.

The volume will undoubtedly lead to greater interest in this family, because of the thoroughness of the coverage here. It is unfortunate that such volumes are so rarely produced, and that often lifetimes are required to do so. The color production is useful, but suffers from some poor registration and a coarser half-tone screening than desirable. All in all, it is a splendid contribution.

—R. E. Woodruff